Problem **3**

In this problem, we have two linkages AB, and BC that are pinned together. Linkage AB is also pinned at A and BC, can slide horizontally at C, they're both have one meter long, and they form an angle with the horizontal of 30 degrees, we're asked to find the relative velocity of B with respect to C. So in order to do this, we first need to determine the velocity at B and C, we know the velocity at C, the C is equal to one meter per second in the i hat direction, we're going to define x as being positive that way, why positive this way and a positive rotation in that direction. Now that we know VC, we need to determine VB. And this is how we determine VB. So we have two linkages. So we're going to apply the velocity equations at both linkages. So let's start with link one. So one, we know that VB is going to be equal to omega A B cross R B with respect to a. Again, this is because a is pinned, so there is no velocity at a. We can plug in magnitude of omega A B is and then omega AB is in the negative k hat direction, as we know, because this will be, since this is moving to the right, these two bars will flatten out, which means that this whole thing is rotating in this direction, which is opposite to our positive direction. So I extracted the magnitude and the direction to get the whole vector. So I can get rid of the cross product. And then this is going to be crossed to the radius of r of B with respect to A, which is this radius over here. So this is r of B with respect to a. And that has the following form. One cosine of 30 degrees, plus one sine of 30 degrees, the j hat direction, and sorry, this is in the i hat direction. So again, I just split it into the two components x and y. They're both positive. So if I take the cross product, the magnitude of omega A B times sine of 30 degrees in the i hat, minus cosine30 degrees in the j hat. This is my first expression for VB. Right. Now I'm going to use Creighton, get another expression because again, I don't know omega AV, right? I need to use this other link and the velocity c here to determine vb. So from link to VB is equal to b c, plus omega b c cross r of B with respect to C. So again, we have this term in here now because this point is actually moving. So it's not pinned like a it's moving. So we need to include that velocity. So the C is going to be one meters per second in the i hat direction. We have it over here, plus the cross product of omega BC. And again, this is the magnitude and I split it from its direction, which is in the k hat direction, because that is positive cross the radius, so this here is going to be r of B with respect to c, which in this case, points this way, our V with respect to C. So what we need to do is it is essentially the same as this radius because it's symmetric, but the x component actually points in the negative direction. So negative one cosine of 30 degrees plus one sine of 30 degrees. And I forgot the directions this is in the j hat direction. And this is in the i hat direction. And I have gotten rid of this, I've separated this. So we can actually do the cross product. And it gets me the following equation, one in the i hat plus omega BC, times negative sine of 30 degrees in the i hat minus cosine of 30 degrees in the j hat direction. And so now I can equate vb. So one, the B is equal to two, v B. So this is essentially this VB over here, this expression is equal to this because VB needs to be the same value, which gets me Which gets me to equations because I have two components. So I have i hat components. So this leads to, and then another equation is these two components over here. So these are the following two equations that I get omega A B, sine of 30 in the i hat direction, 30 degrees, is equal to negative omega BC, sine of 30 degrees in the i hat direction plus one. And then we have negative omega A B, cosine of 30 degrees in the j hat direction, is equal to negative omega BC cosine of 30 degrees in the j direction. Now you can see that we can get rid of these unit vectors. Now because they're the same in both equations, we can also get rid of cosine 30, over here, because it's present on both sides. And the first thing we can pull is that the magnitude it should all be magnitudes. Nine to the mega a, b, is equal to the magnitude of omega BC. These should all be magnitudes, because I pulled it out of the cross product, and I left the direction outside. So over here, I pulled out the direction, I pulled out the direction over here to just leave it in terms of the magnitude. So again, we can't tell if this is positive or negative. But we know that the magnitudes are equal, so they're going to have the same magnitude. And if we look at the drawing back here, we can tell that one is going to spin this way one is going to spin the other way. So they have opposing signs. So we can also say that the vector omega a, b is going to be the negative of omega BC. Right, and this is the full expression. So same magnitude, but different sign is actually opposite in the opposite direction. And with the other equation, so with this equation up here, we can substitute and we get the following: omega a, b, is equal to one over two sine of 30 degrees, one radian per second. So from here, we now know that omega A B is equal to negative omega BC, which is equal to one radian per second in the k hat direction. And then omega a, b is the first one we said was rotating in the negative direction, so we actually have to add a negative in front over here. And now that we know omega A B, we can find the Vb. So V B is going to be equal to we're just going to use the left side because it's a simpler equation. We said that this is v b omega A B cross of RFP with respect to a right. So this is omega A B cross R B with respect to a. And we know just copy this equation over here. We now know the magnitude of omega A, B, right? This is just going to be one radian per second. And we also know that the relative velocity B, B with respect to c is equal to v b minus b, c. This is going to be equal to. So we saw that cross product, this is just going to be equal to omega A B times sine of 30 degrees and the i hat minus cosine of 30 degrees in the j hat. And we know that this here is going to be one radian per second times sine of 30 degrees in the j hat minus cosine of 30 degrees in the i hat minus one radian or meter per second sorry, in the I had. So again, this here is VB. This is V c. And we could simplify this so we can plug in the signed terms, we get that v b with respect to c is equal to negative 0.5. I had minus 0.866 and the j hat meters per second and this is our final relative velocity